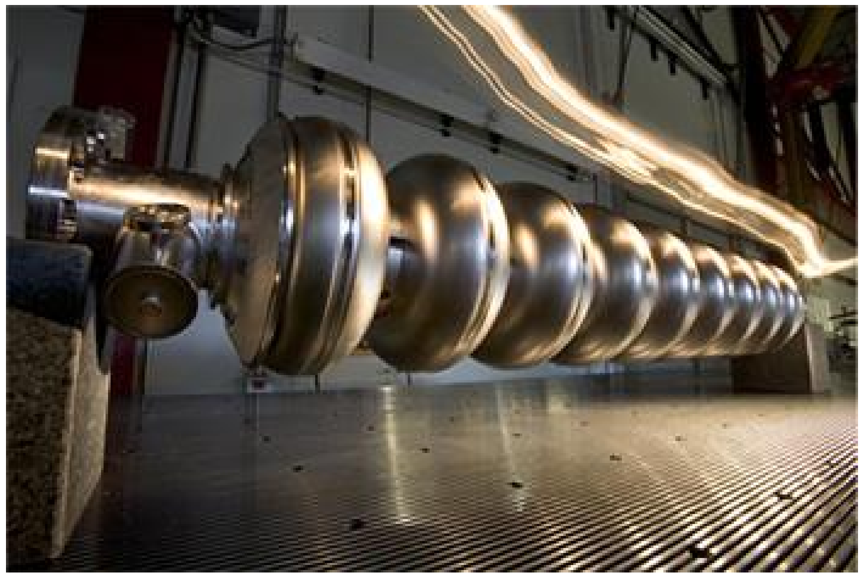
Control of detuning in superconducting cavities



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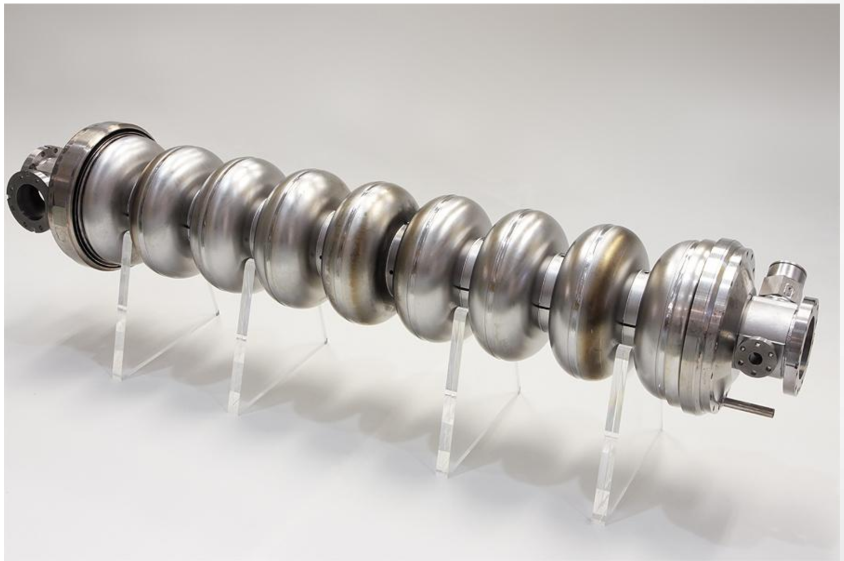
Summer student meeting
7/9/2013

Outline

1.Introduction to detuning of the cavities

2.How to control detuning

3.My goals

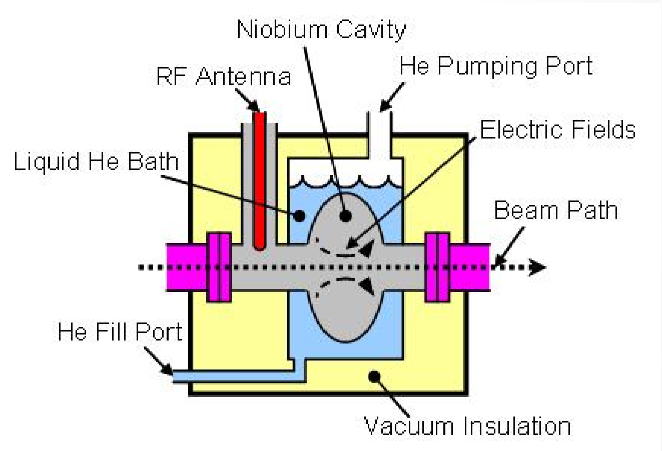


Superconducting cavities (SC)

- Operate at HF modes (1.3 GHz)
- Bandwidth ~200 Hz
- Niobium at T = 1.8K
- RLC circuit behaviour:

$$\frac{d^2 y}{dt^2} + \frac{R}{L}\frac{dy}{dt} + \frac{1}{LC}y(t) = \frac{1}{L}u(t)$$

u – forward signal ; y – probe signal;

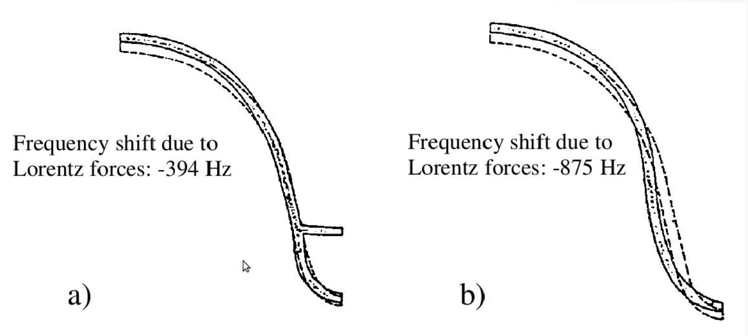


Detuning in cavities

1. Lorentz force detuning
   - deterministic nature:

$$\frac{\omega_0 - \omega}{\omega_0} = \frac{\int\limits_{\Delta V} \left(\epsilon_0 |\vec{E}_0|^2 - \mu_0 |\vec{H}_0|^2\right) dV}{\int\limits_{V} \left(\epsilon_0 |\vec{E}_0|^2 + \mu_0 |\vec{H}_0|^2\right) dV}$$

   - contracting the cell near iris



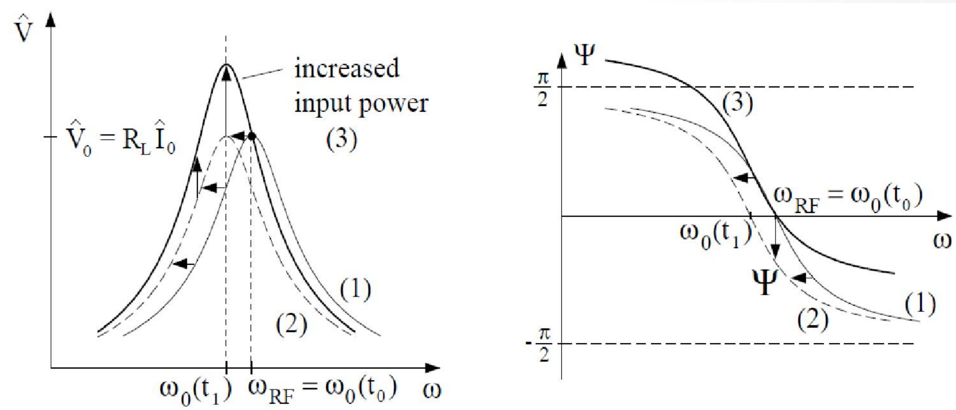
Deformation of cavity cell with stiffening ring
gradient: 25 MV/m
a) with stiffening ring
b) without stiffening ring

2. Microphonics
   - stochastic process
   - sources: helium pressure variations, machinery, traffic
   - mechanical bandwidth of noise up to 1 kHz

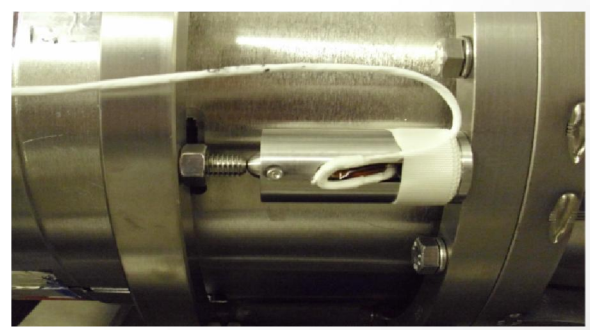
How to control detuning?

1. Adjusting the input power
   - Energy consuming
   - Costs for SC accelerator

   are increased by 10 to 20 %



2. Feedback or feed-forward with piezo-attentuator:
   - Latency up to 1 ms
   - resolution 1/100 nm

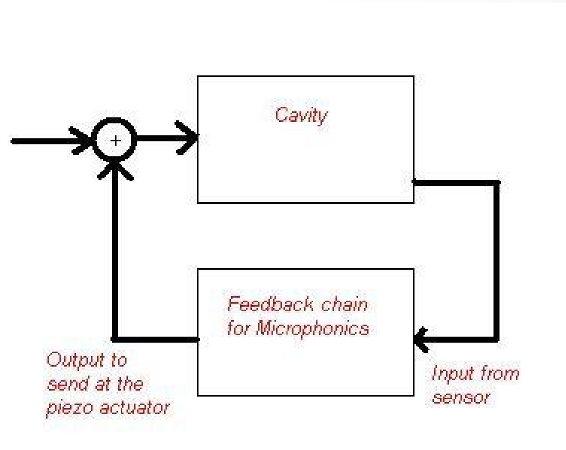


Piezo attentuator

Process of microphonics control

The control process:

1. Getting a probe IF signal y(t)
2. Cavity: $\frac{d^2y}{dt^2}+\frac{R}{L}\frac{dy}{dt}+\frac{1}{LC}y(t)=\frac{1}{L}u(t)$
   Numerical solution using Virtex 4 board
   => getting forward signal u(t)
3. Compensation of the shape distortion using piezo



Virtex 4 board:

- FPGA chip
- VHDL programming language
- 2 independent 14 bits ADC channels
- 2 independent 14 bits DAC channels

A) *B)*

Xilinx® XtremeDSP Development Kit, Virtex-4 Edition.
A) With case. B) Without case

My goals

1. Improving speed of the existing cavity simulator
2. Building microphonics controller (inverse problem)
3. Microphonics measurements using real cavities, including SSR1 cavity